

How deep is our knowledge: deceptions and reflections

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ABSTRACT

This work summarizes the actions taken in agricultural mechanization, a third year course in agricultural engineering, to enhance reflective learning and deep thinking in a variety of dimensions: depth of technical background, improving student performance, and enrichment of lecturer evaluation.

Keywords: superficial knowledge, B-learning, Error propagation, consensual evaluation.

To educate human beings capable of creating a better world, is the problem of forming human beings that possess an open mind and a cheerful mood....The ability to set goals and direct the energies to it, cannot develop under a rigid discipline or under absolute freedom^[1].

1. INTRODUCTION

For the last 15 years now some of us have been lecturing on engines, agricultural machinery, slowly but markedly developing into mechatronics, precision agriculture and robotics; the rest of us have come into this business much more recently and so for them it is much more the natural way.

We have witnessed the transition among three study plans from very rigid and predefined, to a wide spread content and superficial dedication, and more recently traveling from lecturing to learning processes.

Locally, it is of no less interest the evolution occurred in education in the last five years driven by a high number of

innovation activities^[2-6] supported by our university which concern student contests and congresses, the onset of more and better established workshops and learning communities, cross-link activities between high school, professional and university members, and transnational programs (<http://www.ucd.ie/tabe/>).

Information technologies and institutional learning platforms are nowadays ubiquitous, with ever increasing free access courses and materials on the web, making it difficult to segregate fruitful from waste education. Some studies systematically compare traditional with blended learning with improved results for the latter compared to the former^[7].

2. OBJECTIVES

This paper tries to reflect on several questions: 1) how deep we know what we think we know? 2) Are we aware of the consequences of error propagation in our reasoning and decision making processes? 3) How many evaluators are needed when trying to assess the quality of discussion questions formulated by students?

3. MATERIAL AND METHODS

In order to face the first question we have requested students from high school, and engineering to draw a bicycle under a mechanical and functional approach.

For the second, we took advantage of the experimental measurement that were carried out during the practical lessons on Agricultural Machinery in the first semester of 2010-2011 belonging to Agricultural Engineering studies at the UPM. Since such subject is followed by 4 different groups of students

(100 in total). The use of a blended learning platform^[8] that enables automated correction and simultaneously allows much tighter relation between lecturers and students was fundamental for this purpose.

For the third, we decided to request students to formulate an open response question through the learning platform^[8], in relation to agricultural mechanization practice (as derived from practical lessons) and sustainability, and our four lecturers were requested to evaluate using the same 4 level scale (0-3) in order to assess the agreement among us.

Table 1. Rating of discussion questions.

Rate Question	
undelivered / absurd	0
technical but of little interest / single answer,	1
high technical quality with sufficient amplitude	2
exceptional technical relevance open for discussion	3

The global target for the study being the enhancement of reflective learning and deep thinking in a variety of dimensions: depth of technical background, improving student performance, and enrichment of lecturer evaluation.

4. RESULTS

In this paragraph we report sequentially the main results concerning the above mentioned questions:



Figure 1: Draft and prototype of a bicycle as designed by Leonardo Da Vinci.

Bicycle designs

Figure 1 shows draft and prototype of a bicycle as designed by Leonardo Da Vinci^[9]. The selection of such device as the paradigm for assessing the depth of technical background at early ages (high school level) compared to engineering students is not random. It fulfills a number of requirements such as: worldwide spread device and age independent use; more than five centuries of development that has lead to a very robust final design which can be compared to the evolutionary process of a living organism^[10].

In the case of the drafts made by high school students, the most remarkable result on bicycle design was the unfeasibility of proper function, making the own students surprised about the superficiality of their knowledge on a daily use tool. In spite, most of engineering students provided straight forward

functional designs; all of them much more similar, the artistic view is lost.

Error Propagation

Error in science and engineering does not mean a mistake. It rather means inevitable uncertainty that happens because of empirical measurements and cannot be perfectly corrected. All measurements in practice and even in principle have some error associated with them; no measured quantity can be determined with infinite precision and zero deviation. Without proper error analysis, no valid scientific conclusions can be drawn. In fact, wrong results can happen if error analysis is ignored: *If it can't be quantified, then it's not engineering, but only a guess*^[11].

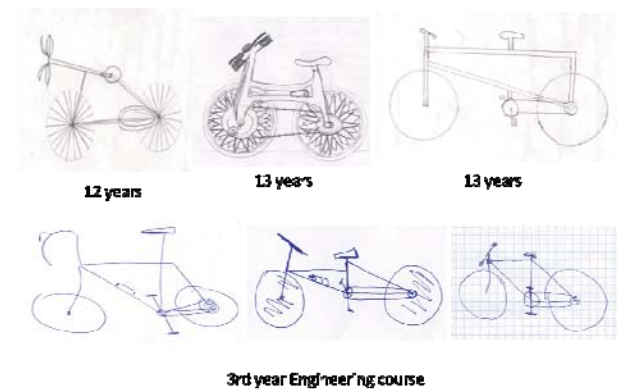


Figure 2: Draft of bicycles made by high school and engineering students.

This point is important when using an automated correction procedure in the B-learning platforms, since final magnitudes derive from a non-linear combination of experimental variables and so uncertainty propagates^[12]. Therefore, a study should be performed and evaluation can be modified according to error tolerance.

In our case, considering a fertilizer similar to that shown in Figure 3, it was possible to assess the consequences of 5% experimental errors in distance among localizers, ground speed, and fertilizer mass flow and its propagation along the computation of a variety of engineering parameters such as work capacity and dose, that relate to machinery calibration. Table 1 shows that errors increase up to 10% in work capacity and 14% in dose.

Agreement among lecturers

Finally, it was decided to assess the agreement among lecturer when trying to assess the quality of discussion questions formulated by students. According to Bertrand Russell^[1], the ideal of competition has negative effects on education because it encourages competition rather than cooperation. So the first thing that seems to aim for the conventional lecturer is to annihilate the imagination of their students. Since imagination recognizes no laws, it is undisciplined, individual and it is not right or wrong, it becomes a problem, especially when the competition requires the establishment of a strict order of merit.

Russell proposes teachers to foster intelligent discussion among students, and even encourages them to read books espousing views different from the instructor, because learning without losing the desire of learning is difficult. Within this context, students were required to formulate discussion questions related to immediate practical lessons.



Figure 3: Fertilizer used as model for experimental error propagation.

Table 1. Error propagation in the computation of work capacity and dose.

exp. Distance (cm)	au(m)	v(km/h)	St(ha/h)	error(%)	Gr(kg/min)	D(kg/ha)	error (%)
19.0	4.8	5.00	2.375	0.0	10.0	253	0.0
19.5	4.9	5.00	2.438	2.6	10.0	246	-2.6
20.0	5.0	5.00	2.494	5.0	10.0	241	-4.8
19.0	4.8	5.25	2.494	5.0	10.0	241	-4.8
19.5	4.9	5.25	2.559	7.8	10.0	234	-7.2
20.0	5.0	5.25	2.625	10.5	10.0	229	-9.5
19.0	4.8	5.00	2.375	0.0	9.5	240	-5.0
19.5	4.9	5.00	2.438	2.6	9.5	234	-7.4
20.0	5.0	5.00	2.500	5.3	9.5	228	-9.8
19.0	4.8	5.25	2.494	5.0	9.5	229	-9.5
19.5	4.9	5.25	2.559	7.8	9.5	223	-11.8
20.0	5.0	5.25	2.625	10.5	9.5	217	-14.0

Figure 4 shows the regression line among each evaluator and the so called average-evaluator. Determination coefficients are all above 50%, that is to say correlation stays between 0.7 and 0.8. Regression equations indicate that there were two groups of evaluators: one with higher slope (more sensitive to differences and higher risk holder) while the other exhibited lower slope (less sensitive to differences, more conservative evaluation).

Table 2 summarizes the correlation coefficient of each lecturer with regard to the average, while Table 3 indicates the number of questions evaluated (N), the average value in 3 point scale, the standard deviation and the average value in decimal basis.

correlation coef.	11	12	13	14
avg_lecturer	0.777	0.806	0.724	0.759

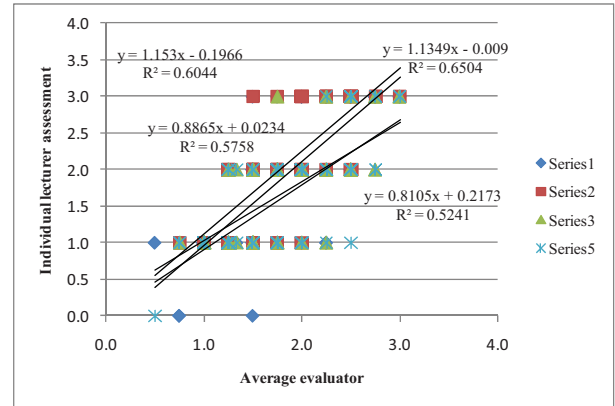


Figure 4. Comparison of question rating with regard to average-lecturer.

From Table 3 it can be concluded that lecturer number 2 gave higher scores than the rest.

Table 3. Number of questions rated by each lecturer, average score and standard deviation and score in decimal basis.

	11	12	13	14
N	107	100	104	107
AVG	1.8	2.0	1.6	1.5
STD	0.8	0.8	0.6	0.7
BASE 10	5.9	6.5	5.4	5.1

According to the students, the possibility of formulating discussion question is engaging, but it is clear from the dispersion in evaluation results that several lecturers are needed to allow precise average quantitative scoring.

5. CONCLUSIONS

Several conclusions have been derived from this study: 1) depth of technical background should be evaluated at high school by means of making students reflect on the mechanical elements and functional details of common use devices, allowing high school skills to come into university and university to reformulate high school skills. 2) The quantification of error propagation can be used as an additional measurement of the quality of responses for practical lessons, and can readily be incorporated into automated correction systems in b-learning platforms. 3) There is a large interest in incorporating high level discussion question which are difficult to be rated and thus the assessment by an expert committee becomes mandatory. We propose not to avoid the challenge but to limit the risk of poor evaluation and student deception.

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